Next Generation Hard X-ray

[Draft - 07/25/11]

Name of Technology (256 char)	Large-Area, finely pixelated,thick CZT Detectors	Low-Noise, Low-power ASICs for Solid State Detectors	Active shield using avalanche photdiode
Brief description of the technology (1024)	A large array (4.5 m^2) of imaging (0.6 mm pixel) CZT detectors are needed to perform the first hard X-ray survey (5-600 keV) with well-localized (<20" at 5-sigma threshold) sources down to 0.06 mcrab (5-150 keV). Thick CZT detectors (0.5 cm) allow broad-band energy coverage for GRBs and black holes, from stellar to supermassive.	Low power ASICs (<20 microW/pixel) are needed to provide accurate time of arrival and energy for each photon but with low aggregate power per square meter.	BGO scintillators read out by two light guides on opposite edges, each coupled to two Avalanche Photo Diodes used as active shields to reduce in flight atmospheric albedo and cosmic-ray induced backgrounds.
Goals and Objectives (1024)	The goal is to achieve CZT detectors with 0.6mm pixels, 4 keV trigger threshold, and 2.4' angular resolution when used as imagng detectors for a 2m focal length coded aperture telescope.	A reduction of power consumption by a factor of ~4 compared to current designs (e.g. NuSTAR) is needed to implement the large detector array with typical solar panels and batteries. A low energy threshold of ~5 keV is needed.	The goal is to minimize cosmic ray induced internal background and to reduce the physical size of the active shielding system.
TRL	TRL is 6. Prototype detectors, with2.5mm pixels and ~15 keV threshold and tiled array packaging, have flown on ProtoEXIST in 2009. Detectors with 0.6mm pixel size and ~6 keV threshold scheduled forballoon flight test in Sept. 2012.	TRL is 5. Portions of the functionality have been demonstrated but a full prototype that meets both the noise and power requirements has not yet been produced.	TRL is 5. BGO shields and APD readouts are well developed, but the compact packaging has not been demonstrated. Prototype designs are planned for flight.
Tipping Point (100 words or less)	Designs have reached TRL 6. Successful balloon flight test with 0.6mm pixel detectors close tiled in a 16cm x 16cm imaging array will increase the TRL to 7-8.	The lower-power ASIC is the key requirement, but a more compact ASIC readout using microvias rather than wirebonds is highly desirable. Successful design and fabrication will allow systems to be tested in relevant environments.	Prototypes to be flown.
NASA capabilities (100 words)	NASA's capabilities support test but pixel arrays are custom procurements under development by University groups with support from NASA and commercial sources.	NASA (or DoE) has not yet developed an ASIC that meets these requirements. The NuSTAR ASIC, designed and developed at Caltech is the prototype but does not meet the power or more compact readout (with microvias) requirements.	NASA has experience with scintillators and test capabilities. Scintillators and avalanche photodiodes can be procured from commercial sources.
Benefit/Ranking	Ranking: iii. Thick pixelated CZT detectors will provide good position and energy resolution for an unprecedentedly broad energy range.	Ranking: iv. The ASIC is the principal limiting factor for the power budget, energy resolution, time resolution. ASIC performance directly translates into mission performance improvements.	Ranking: ii. Compact active shielding is important for NASA astrophysics missions and can produce reductions in mass and volume.
NASA needs/Ranking	Ranking: iv. Pixelated CZT detectors of this type can be applied to various missions that need large area wide-field imaging and spectroscopy with broad energy coverage.	Ranking: iv. Low power, low-noise ASICs coupled with pixelated CZT detectors of this type can be applied to various missions that need large area wide-field imaging, and spectroscopy.Microvia readout is particularly important for compact packaging.	Ranking: ii. Compact active shielding is important for NASA astrophysics missions and can produce reductions in mass and volume
Non-NASA but aerospace needs	Ranking: iii. Space-based monitoring programs in other agencies	Ranking: iii. Space-based monitoring programs in other agencies	

Non aerospace needs	Ranking: iii. Nuclear medicine and ground-based nuclear materials detection applications	Ranking: iii. Nuclear medicine and ground-based nuclear materials detection applications	
Technical Risk	Ranking: ii. Technical risk is low. The design principles are generally understood but progress comes through design iterations to refine performance based on completed units.	Ranking: iii. Technical risk is moderate given access to (rare) analog ASIC design expertise. The history of analogous flight projects shows this task must not be underestimated.The main challenge is to get low power with low noise.	Ranking: i. Technical risk is low.
Sequencing/Timing	Ranking: iv. CZT detectors with the required pixel size are currently being adapted from those flown on ProtoEXIST1. ProtoEXIST2 will incorporate 0.6mm pixels over tiled detector for balloon flight test in 2012.	Ranking: iv. ASICS based upon the NuStar ASIC are currently being adapted. Reduced power will be easier to achieve than microvia readout.	Ranking: iv. This concept will be tested in ProtoEXIST 2-3 and compared with existing active shielding concepts.
Time and Effort to achieve goal	Ranking: iv. 3 year collaboration between University, industry and NASA	Ranking: iv. 3 year collaboration betweenUniversity, industry and NASA	Ranking: iv. 3 year collaboration between University, industry and NASA